NERRS Science Collaborative Progress Report for the Period 9/1/2013 through 2/28/2014

Project Title: A collaborative approach to address larval supplies and settlement as critical early life-history issues during restoration of native Olympia oysters (*Ostrea lurida*) in Coos Bay and the South Slough estuary

Principal Investigator(s): Dr. Steven Rumrill

Project start date: Nov 2010

Report compiled by: Steven Rumrill / John Bragg

Contributing team members and their role in the project:

Integration Leader: Frank Burris, Extension Watershed Educator
Oregon State University Extension Service
Gold Beach, OR
Role in project: Facilitation of interactions between the stakeholders (Olympia Oyster Restoration Advisory Committee) and project team members. Mr. Burris has expertise with community stakeholder discussions in rural environments, and will provide for integration and leadership through the joint fact-finding / structured decision-making process.

Co-Principal Investigators: Dr. Craig Young, Professor of Biology
University of Oregon / Oregon Institute of Marine Biology
Charleston, OR
Role in project: Director of OIMB and collaborating project scientist with particular expertise in the reproductive biology and larval ecology of marine and estuarine invertebrates. Dr. Young will serve as the primary graduate thesis advisor for one graduate student (module 1 / reproduction and reproductive output) supported by the project.

Dr. Alan Shanks, Professor of Biology
University of Oregon / Oregon Institute of Marine Biology
Charleston, OR
Role in project: Collaborating project scientist with particular expertise in larval behavior, dispersal, and tidally-driven transport in estuaries. Dr. Shanks will serve as the primary graduate thesis advisor for one graduate student (module 2 / larval supplies and dispersal) supported by the project.

Dr. Richard Emlet, Professor of Biology
University of Oregon / Oregon Institute of Marine Biology
Charleston, OR
Role in project: Collaborating project scientist with particular expertise in larval development, hydromechanics, larval settlement, and metamorphosis. Dr. Emlet will serve as the

primary graduate thesis advisor for one graduate student (module 3 / larval settlement and metamorphosis) supported by the project.

Jamie Doyle, Marine Community Development Leader
Oregon Sea Grant Extension Program (Coos County)
Myrtle Point, OR
Role in project: Work with project team to develop a series of presentations, fact sheets, briefing materials to ensure that the stakeholders and scientists share a common level of understanding about the biology and ecology of Olympia oysters. Ms. Doyle has expertise with marine resource policy and management, community education, and outreach, and she will provide assistance to the Integration Leader with the SDM process.

John Bragg, Communications Leader
Coastal Training Program Coordinator
South Slough National Estuarine Research Reserve
Charleston, OR
Role in project: Work to conduct regular and routine communications among members of the project team and the NERRS Science Collaborative, to compile and summarize discussion notes generated during OORAC meetings, serve as co-author of the NSC Biannual reports, and assist with development of presentations, fact sheets, and briefing materials. Mr. Bragg has expertise with condensation of technical research materials into summary sheets, and will provide an interface for the project with the South Slough National Estuarine Research Reserve. John will also provide assistance to the Integration Leader with the SDM process.

A. Progress overview: State the overall goal of your project, and briefly summarize in one or two paragraphs, what you planned to accomplish during this period and your progress on tasks for this reporting period. This overview will be made public for all reports, including confidential submissions.

Project Goal: The overall goal of this project is to investigate the importance of reproductive timing and output, larval supplies, estuarine retention time, settlement, and recruitment as factors that potentially limit recovery of self-sustaining populations of *Ostrea lurida* in Coos Bay and the South Slough estuary. Our specific objectives are to: (A) bring together a diverse group of stakeholders and user-groups to form an Olympia Oyster Recovery Advisory Committee (OORAC); (B) determine the suite of intrinsic ecological, reproductive, and early life-history factors that contribute to the success of Olympia oyster restoration efforts in Coos Bay/South Slough; and (C) integrate the perspectives and collective knowledge from resource agencies, academic investigators, mariculture operators, restoration practitioners, and recreational stakeholders during development of an Olympia Oyster Conservation and Recovery Strategy for Coos Bay.

Accomplishments: Two graduate students at the University of Oregon / Oregon Institute of Marine Biology (OIMB) continued their thesis work focused on the reproductive biology and

larval ecology of Olympia oysters (*Ostrea lurida*) in the Coos Bay estuary (Oregon). Cate Pritchard (MSc.; Dr. Alan Shanks thesis advisor) completed her investigation of the physical hydrodynamic characteristics of the greater Coos Bay estuary and how they influence the supplies, dispersion, export, and retention of *O. lurida* larvae. Rose Rimler (MSc candidate; Dr. Richard Emlet thesis advisor) continued to document the seasonal pattern of larval settlement, metamorphosis, survival, and growth at multiple locations throughout the Coos estuary. Both of the OIMB graduate students are supported by the NERRS Science Collaborative. During the current reporting period (1 Sep 2013 to 28 Feb 2014) Cate Pritchard and Rose Rimler continued to work together to monitor and analyze a set of integrated field experiments to assess the supplies and settlement of *Ostrea lurida* larvae at multiple locations within Coos Bay. They analyzed datasets from a series of replicated ceramic settlement plates (attached to PVC pipe) and replicated larval settlement tubes (five per site) placed into the soft sediments in the lower intertidal zone along the edges of the primary tidal channel at five locations: (A) Empire tideflats; (B) Haynes Inlet; (C) downtown Coos Bay; (D) Coalbank Slough; and (E) Catching Slough.

Over the period from Sep to Dec 2013, Cate completed the laboratory work and statistical analysis of her earlier datasets, and she compiled a literature review that focuses on the biology and ecology of Olympia oysters. Data from settlement tubes and larval traps were used to examine temporal and spatial variation in larval supplies of *Ostrea lurida* at different locations throughout Coos Bay. Cate also used a combination of morphological analyses and DNA barcode techniques to identify other bivalve larvae to the lowest taxonomic level and to interpret their local patterns of distribution in Coos Bay. On 5 Dec 2013 Cate successfully defended her MSc. thesis titled "*Distribution of Larval Bivalves in the Coos Bay Estuary*." The primary findings from her research are: (1) Olympia oysters can be considered as ecosystem engineering species that provide important habitats and processes in Oregon estuaries; (2) hydrodynamic processes redistribute the planktonic larvae of Olympia oysters and contribute to substantial spatial and temporal variability in larval supplies; and (3) observations of larval bivalves from plankton tows and tracking of GPS drogue drifters support the hypothesis that formation of a null zone within the estuary may be a key factor in determining the distribution of larvae and slow recovery of populations in Coos Bay. The abstract from Cate's MSc. thesis is included as Appendix I.

During the fall and winter (Sep 2013 to Feb 2014), Rose Rimler continued to analyze her data on variability in larval settlement patterns by *Ostrea lurida* collected during the 2012 & 2013 field seasons. Heavy settlement of *O. lurida* spat was observed in early Jul 2013, and Rose analyzed the survival and growth of these sub-adults by the recovery and examination of settlement plated deployed into different regions of Coos Bay. Her observations indicate that the planktonic larvae of *O. lurida* are generally restricted to the upper region of Coos Bay, and that sites where larval settlement is high correspond directly with sites where adult Olympia oysters are abundant. In addition, the survival of post-larva and juveniles is also high at sites where adult oysters are abundant. These observations indicate that future restoration and recovery efforts will most likely be successful at the sites where the density of adults is already high. Rose presented a poster titled "*Larval supplies, settlement, and post-settlement mortality as determinants of the spatial distribution of Olympia oysters in Coos Bay, OR*" during the biennial Ocean Sciences Meeting (Honolulu, HI; 23-28 Feb 2014). The poster is included in this report as Appendix II. Rose will continue to work on these aspects of the biology of larval settlement and early post-larval life in Olympia oysters until her thesis is completed in the spring of 2014.

B. Working with Intended Users:

- Describe the progress on tasks related to the integration of intended users into the project for this reporting period
- What did you learn? Have there been any unanticipated challenges or opportunities?
- Who has been involved?
- Has interaction with intended users brought about any changes to your methods for integration of intended users, the intended users involved, or your project objectives?
- How do you anticipate working with intended users in the next six months?

Integration of input from intended users: Steve Rumrill met individually and in small groups with several members of the Olympia Oyster Restoration Advisory Committee (OORAC) over the reporting period (Sep 2013 – Feb 2014) to discuss the progress made by the graduate students and the implications of their findings toward Olympia oyster restoration and other oyster recovery efforts in Oregon estuaries. Rumrill met with the acting Research Coordinator for South Slough NERR (A. Helms; 27 Sep 2013), with Dr. B. Dumbauld (USDA/ Agricultural Research Service; 29 Oct & 4 Dec 2013) and with D. Landkammer (OR Sea Grant Aquaculture Extension Specialist; 6 Sep & 4 Dec 2013) to provide an update on the work conducted by the two OIMB graduate students supported by the NERRS Science Collaborative project (R. Rimler, C. Pritchard), to discuss ecosystem services provided by Olympia oysters, and to further discuss the prospects for future research efforts that focus on restoration and recovery of Olympia oyster populations in Oregon bays and estuaries. Input was gained during these discussions about the need to develop new information about the role of Olympia oyster beds to serve as habitat areas for estuarine fish and motile invertebrates that are important members of ecological communities in Oregon estuaries. Rumrill also held conversations with OORAC members Dr. L. Hoberecht (Regional Coordinator, NOAA Aquaculture Center) and D. vander Schaaf (Coastal Conservation Leader, The Nature Conservancy) about their joint proposal titled "*West Coast Native Oyster Workshop #4: Technical Transfer of New Information about Restoration and Recovery of Olympia oysters (Ostrea lurida) along the Pacific Coast*." It was agreed that the proposal will be re-submitted to the NOAA Restoration Center to seek support for the workshop in the fall of 2014 or winter of 2015. The WCNOW #4 will provide an ideal forum to discuss progress made about our understanding of the reproductive biology and ecology of Olympia oysters, and to present the new technical information generated by the three graduate students (M. Oates, C. Pritchard, R. Rimler) supported by the NERR Science Collaborative Project.

Steve Rumrill met with a member of the commercial shellfish industry (OORAC member / A. Barton / Whiskey Creek Shellfish Hatchery) on 14 Nov 2013 to discuss plans for production of 200-300 bags of Olympia oyster cultch during the early summer season of 2014. These bags of new Olympia oysters would be produced by the hatchery working under the instruction of the collaborative science team, and the living cultch would be transported into the South Slough NERR as an enhancement of their existing population of *Ostrea lurida* at the Long Island Point grow-out area. Transport of the new bags of *O. lurida* cultch is dependent upon receipt of a clean health inspection report, approval of an ODFW shellfish transfer permit, and approval by the South Slough NERR.

Unanticipated challenges and opportunities: During the fall and winter, investigators from state universities and mariculture support groups in Oregon, Washington, and California contacted the Oregon Department of Fish and Wildlife / Shellfish Program to seek further assistance with development of new research proposals that focus on aspects of the biology, biogeochemistry, ecology, and mariculture of Olympia oysters. The ODFW / Shellfish Program provided direct

assistance with development of the new research proposals, with the logistics of their proposed sampling plans, and by providing letters of support. This high level of interest in new collaborative research presents a good opportunity to develop and initiate additional research that is focused on recovery of Olympia oyster populations in the future.

In Feb 2014, the Oregon Department of Agriculture (ODA) granted approval for a new commercial oyster mariculture lease in Netarts Bay (OR) that may include cultivation of native Olympia oysters. Approval of the new lease was made possible via a court-mediated agreement between ODA and ODFW to allow the commercial cultivation of native Olympia oysters within a private lease area managed by ODA located in Netarts Bay, OR. The ODFW Shellfish Program currently prohibits the recreational harvest of Olympia oysters from public waters, but ODFW does not have regulatory authority for the cultivated oysters (including Olympia oysters), clams, and mussels that are grown for commercial purposes in leased plats. Steve Rumrill continued to work with OORAC members Ken Phippen and Michelle Mullin (NOAA / NMFS coastal ecologists) and staff members from ODA Shellfish program (John Byers & Alex Manderson) to help develop agency guidance on the establishment of commercial-scale Olympia oyster beds in the estuarine environment. In particular, new information is needed to design Best Management Practices for Olympia oyster mariculture areas to minimize disturbance to established eelgrass (*Zostera marina*) and other estuarine organisms. Establishment of a commercial mariculture grow-out bed of Olympia oysters in Netarts Bay poses an unexpected opportunity to incorporate recent findings generated by the current NSC project into the ODA regulatory permit. Steve Rumrill is currently working with OORAC Members (Dr. B. Dumbauld: USDA/ Agricultural Research Service; D. Landkammer (OR Sea Grant Aquaculture Extension Specialist) and the Director of the Oregon State University – Marine Resource Management program (Dr. F. Conway) to seek grant funds to support a MRM graduate student who will focus on the topic of oyster/eelgrass interactions in Pacific northwest estuaries.

Changes to methods of integration: Members of the project team continued to hold effective discussions with the stakeholders by meeting in small groups or on a one-on-one basis over the last several months (Sep 2013 to Feb 2014). The stakeholders continue to ask questions about progress made by the OIMB graduate students and to share their perspectives about the factors that limit recovery and restoration of Olympia oyster populations. In particular, questions have been raised by the US ARMY Corps of Engineers and the Oregon International Port of Coos Bay about the role of sedimentation on larval settlement by Olympia oysters in the lower intertidal and subtidal zones of Coos Bay. The new research conducted by OIMB graduate student Rose Rimler will address this question by making the comparison between larval settlement and rates of growth for different locations in Coos Bay that experience different levels of sedimentation. This issue is important because the primary navigational channel in Coos Bay is routinely dredged by the US Army Corps of Engineers for the purpose of maritime commerce, and the Oregon International Port of Coos Bay is interested in further deepening and widening of the channel and turning basin to support potential expansion of the port facilities and their dockside infrastructure for commercial shipping of cargo.

During the next six months: During the next six months we will maintain periodic contact with intended users and stakeholders to: (1) provide updated NSC fact-sheets that summarize the new work on reproduction and larval ecology of Olympia oysters in Coos Bay; (2) continue to collaborate with an outside investigator (D. Sutherland, Univ. Oregon) to refine an existing numerical hydrodynamic model of the Coos Bay estuary, and conduct particle tracking

scenarios to simulate the advective movement of Olympia oyster larvae within the estuarine tidal basin; (3) work with an OIMB graduate student to develop an individual-based model to simulate the swimming of planktonic oyster larvae in the tidal waters of Coos Bay; (4) work with members of the science team and an OIMB graduate student to conduct the survey of Olympia oyster populations along the shoreline of Coos Bay to identify the specific location of index sites that can be used to monitor recovery; (5) work with the project team to integrate the three components of the reproductive biology (Module 1 / reproduction and brooding; Module 2 / larval supplies and dispersal; Module 3 / larval settlement) into the framework for the local Olympia Oyster Conservation and Recovery Plan; (6) make arrangements with the South Slough NERR and the Whiskey Creek Shellfish Hatchery for the generation of 200-300 bags of Olympia oyster spat to be placed within the South Slough NERR or another location in Coos Bay; and (7) re-convene the OORAC to initiate discussions and gain their input about development of the local conservation plan for Olympia oysters in Coos Bay.

C. Progress on project objectives for this reporting period:

- Describe progress on tasks related to project objectives for this reporting period.
- What data did you collect?
- Has your progress in this period brought about any changes to your methods, the integration of intended users, or the project objectives?
- Have there been any unanticipated challenges, opportunities, or lessons learned?
- What are your plans for meeting project objectives for the next six months?

Progress and data collection: Over the past six months (Sep 2013 to Feb 2014) the two graduate students from the Oregon Institute of Marine Biology (Cate Pritchard, Rose Rimler) continued their thesis work on the reproductive biology and larval ecology of Olympia oysters in the Coos Bay estuary. Early input received from the OORAC was incorporated into the overall objectives and design for the science activities conducted by these students, and the direction and approach were approved by members of the OIMB graduate thesis advisory committees. Several different types of data were collected and analyzed by members of the science team over the fall and winter months. Cate Pritchard (Module 2 / larval supplies and dispersal) continued to analyze time-series data to describe seasonal variability in ambient water parameters in different regions of Coos Bay, and to characterize the abundance, supplies, and dispersal of Olympia oyster larvae at strategic locations in Coos Bay. Cate also analyzed new information about the taxonomic identities of larval bivalves in an effort to interpret their local patterns of distribution in Coos Bay. This effort included work on the taxonomic identities for over 100 larvae using morphological and DNA barcode techniques. Cate successfully defended her M.Sc. thesis in Dec 2013. Rose Rimler continued her work over the fall to conduct monthly assessments of the settlement, survival, and growth of Olympia oysters that recruit onto a series of paired ceramic plates deployed at multiple sites throughout Coos Bay estuary, and to measure bi-weekly differences in larval abundance and settlement at several locations throughout Coos Bay. Rose also worked to analyze records of ambient estuarine water parameters (*i.e.*, temperature, salinity, water level) at strategic points in Coos Bay. The South Slough NERR continued to collect time-series measurements of estuarine water quality parameters (estuarine water temp, sal, cond, pH, DO, Chl-a, turb) at several locations along the estuarine gradient of the South Slough, and they have recently added additional datalogger sites within Coos Bay.

Changes in methods and integration of intended users: The Oregon Department of Agriculture (ODA) recently granted approval for a commercial oyster mariculture lease in Netarts Bay (OR)

that may include cultivation of native Olympia oysters (Feb 2014). Approval of the new lease was made possible via a court-mediated agreement between ODA and ODFW to allow the commercial cultivation of native Olympia oysters within a private lease area managed by ODA located in Netarts Bay, OR. In response to the permit application, the ODFW Shellfish Program (intended user) held discussions with several OORAC members about the implications of this mariculture agreement on the need for further information about the ecological interactions between Olympia oysters and members of estuarine communities (*i.e.*, eelgrass beds, infaunal invertebrates, resident and migratory fishes, waterfowl and shorebirds, etc.). ODFW held an interdepartmental meeting to determine how best to coordinate and address the potential impacts from new commercial oyster leases (11 Dec 2013). There is a pressing need for new information about the ecological impacts of natural beds and mariculture plots of Olympia oysters on eelgrass beds (*Zostera marina*) in the lower intertidal zone and shallow sub-tidal zone. Although these topics are beyond the scope of the current graduate students supported by the NSC project, new data generated by the current students will provide fundamental information about the reproduction and larval ecology of Olympia oysters that will be relevant to future studies about potential mariculture impacts.

Unanticipated challenge, opportunities, and lessons learned: Renewed interest in the mariculture and recreational harvest of Olympia oysters has prompted new investigations into the uptake and incorporation of contaminants into their tissues. The Oregon Department of Environmental Quality (ODEQ) recently added Olympia oysters to the list of bivalves that are routinely monitored at select locations for the analysis of tissue contaminants. Dr. Elise Granek (Portland State University, OR) has developed an interest in the potential for tissues of Olympia oysters to take up contaminants from personal care products released into Oregon's coastal watersheds through municipal wastewater treatment systems and the septic systems of private residences. Dr. Granek contacted Steve Rumrill in Feb 2014 to seek further advice and assistance with the location of suitable populations of Olympia oysters in Coos Bay for the investigation, and he collaborated with Dr. Granek and her colleagues to submit a new proposal to the USEPA to investigate the issue. Information generated by the analysis of potential tissue contaminants will be important in the future in the event that Olympia oysters become more popular for commercial mariculture operations and/or recreational harvests. Recreational collection of Olympia oysters is currently prohibited by the Oregon Department of Fish and Wildlife.

Acidification of ocean waters is rapidly gaining recognition as a global problem caused primarily by emission of greenhouse gasses into the atmosphere and uptake of carbon dioxide by the ocean. Along the coast of Oregon, seasonal upwelling of deep cold acidified ocean waters is linked with the occurrence of hypoxia (low concentrations of dissolved oxygen). The biophysical links between ocean acidification and hypoxia are not well understood and are currently the subject of ongoing research. Academic scientists and natural resource agencies face a difficult problem to communicate the technical issues presented by ocean acidification and hypoxia, to understand how acidification of nearshore ocean waters can influence the carbonate chemistry in Oregon estuaries, and to increase level of understanding about the potential consequences to natural and cultured shellfish. New research activities led by academic scientists from Oregon State University (including OORAC member Dr. C. Langdon, B. Hales, B. Menge, G. Waldbusser, and F. Chan) and partners at the Whiskey Creek Shellfish Hatchery (A. Barton) have placed a clear spotlight on the threats to native and cultivated shellfish due to elevated pCO2 concentrations in the nearshore ocean waters off of Oregon and northern California. In particular, a new research investigation will focus on the capacity for respiration by native (*Zostera marina*) and non-native (*Z. japonica*) eelgrass beds to modify local carbonate

chemistry conditions in Netarts Bay and Coos Bay, and whether eelgrass beds can serve to mitigate the detrimental impacts of acidified ocean waters on cultivated and native oysters and other shellfish.

To address the issue of ocean acidification (OA) and shellfish in Oregon for a group of land-use managers, Steve Rumrill and OORAC member A. Barton (Whiskey Creek Shellfish Hatchery) were asked to deliver a tag-team presentation to the seven members of the Oregon Department of Land Conservation and Development Commission (DLCDC; 14 Nov 2013). The presentation focused on: (1) the impacts and economic losses due to ocean acidification and hypoxia on cultivated oysters inside the Whiskey Creek Shellfish Hatchery; and (2) the recreational fisheries, potential impacts and resilience to OA by populations of native shellfish in Netarts Bay. This issue will most likely be a fruitful topic for further research with Olympia oysters and other shellfish in the future.

Plan for the next six months: During the next six months we will maintain periodic contact with intended users and stakeholders to: (1) provide new NSC fact-sheets that summarize the completed work on reproduction and larval ecology of Olympia oysters in Coos Bay; (2) continue to collaborate with an outside investigator (D. Sutherland, Univ. Oregon) to refine an existing numerical hydrodynamic model of the Coos Bay estuary, and conduct particle tracking scenarios to simulate the advective movement of Olympia oyster larvae within the estuarine tidal basin; (3) work with an OIMB graduate student to develop an individual-based model to simulate the swimming of planktonic oyster larvae in the tidal waters of Coos Bay; (4) work with members of the science team and an OIMB graduate student to conduct the survey of Olympia oyster populations along the shoreline of Coos Bay to identify the specific location of index sites that can be used to monitor recovery; (5) work with the project team to integrate the three components of the reproductive biology (Module 1 / reproduction and brooding; Module 2 / larval supplies and dispersal; Module 3 / larval settlement) into the framework for the local Olympia Oyster Conservation and Recovery Plan; (6) make arrangements with the South Slough NERR and the Whiskey Creek Shellfish Hatchery for the generation of 200-300 bags of Olympia oyster spat to be placed within the South Slough NERR or another location in Coos Bay; and (7) re-convene the OORAC to initiate discussions and gain their input about development of the local conservation plan for Olympia oysters in Coos Bay.

D. Benefit to NERRS and NOAA: List any project-related products, accomplishments, or discoveries that may be of interest to scientists or managers working on similar issues, your peers in the NERRS, or to NOAA. These may include, but are not limited to, workshops, trainings, or webinars; expert speakers; new publications; and new partnerships or key findings related to collaboration or applied science.

- A graduate student supported by the NSC project successfully completed and defended her M.Sc. thesis at the University of Oregon – Oregon Institute of Marine Biology
    - Pritchard, C.E., 2013. Distribution of Larval Bivalves in the Coos Bay estuary, Oregon. M.Sc. Thesis, University of Oregon – Oregon Institute of Marine Biology, Eugene. 155 pp. (Charleston, OR; 5 Dec 2013)

- A graduate student supported by the NSC project delivered a poster presentation during the Ocean Sciences Conference (Honolulu, HI; 23-28 Feb 2014):
    - *Rose Rimler and Cate Pritchard. Oregon Institute of Marine Biology, University of Oregon.* Larval supplies, settlement and post-settlement mortality as

determinants of the spatial distribution of Olympia oysters (*Ostrea lurida*) in Coos Bay, Oregon

- Members of the NSC science team and OORAC delivered a tag-team presentation to the Oregon Department of Land Conservation and Development Commission during their regional tour of environmental and economic issues in Tillamook bay and Netarts Bay:
    - S. Rumrill / Potential vulnerability and resilience of native Olympia oysters and other shellfish in the tideflats of Netarts Bay (14 Nov 2013)

E. Describe any activities, products, accomplishments, or obstacles not addressed in other sections of this report that you feel are important for the Science Collaborative to know.

- The project PI (S. Rumrill) and several members of the OORAC (L. Hoberecht, D. Landkammer, C. Langdon, B. Dumbauld) continue to work with members from private industry (*i.e.*, Pacific Coast Shellfish Growers Association) on development of the Oregon Shellfish Initiative. This cooperative and collaborative initiative is designed to help meet many of the goals of the National Shellfish Initiative, and will likely include a component that is focused on enhancement, restoration, and recovery of Olympia oyster populations in Oregon estuaries.

- The non-native colonial tunicate (*Didemnum vexillum*) has recently become established on the floating docks and piers in Charleston, OR. This invasive species has become widespread in temperate coastal habitats around the world over the past 40 years. Colonies of *D. vexillum* can out-compete native epibenthic organisms and readily overgrow artificial substrata including pilings, boat hulls, floating docks, cables, mooring lines, cultivated shellfish, nets, and aquaculture gear. Consequently, *D. vexillum* are considered as the highest risk impact tunicate species in Puget Sound, and they have been placed on the federal (US Geological Survey) list of Marine Nuisance Species and the Oregon state-wide list of 100 worst invaders. Spread of D. vexillum from the new population in Charleston has the potential to interrupt, slow, or halt the recovery of Olympia oysters along the shorelines of South Slough and Coos Bay. The project PI (S. Rumrill) is currently working with the Oregon Invasive Species Council and a SCUBA team from the US Forest Service (B. Hansen; Dive safety coordinator) to conduct seasonal monitoring and experimental control actions in the Charleston Boat Basin and at other sites along the Oregon coast.

Appendix I. Catharine E. Pritchard (Master of Science; Department of Biology, University of Oregon, Eugene OR; December 2013; 155 pp.)

Title: Distribution of larval bivalves in the Coos Bay Estuary, Oregon

Abstract: Bivalves are considered ecosystem engineers and are important for ecosystem health within estuaries. The Olympia oyster, *Ostrea lurida* was historically important along the Pacific Coast of the United States, but currently has low population abundances along much of its historical distribution. However, despite restoration efforts, little recovery has been observed. Here, we provide a short review of the biology of the species and recent efforts of restorations. We then examine potential contributing factors to limited recovery in the Coos Bay estuary. We noticed distinct variations in larval supply along the bay, and proposed hydrodynamics of the bay could be causing these variations. We then collected observational data on the hydrodynamics of the bay and the distribution of other larval bivalves. These data support the presence of a null zone within the estuary that may be driving the distribution of larval bivalve taxa.

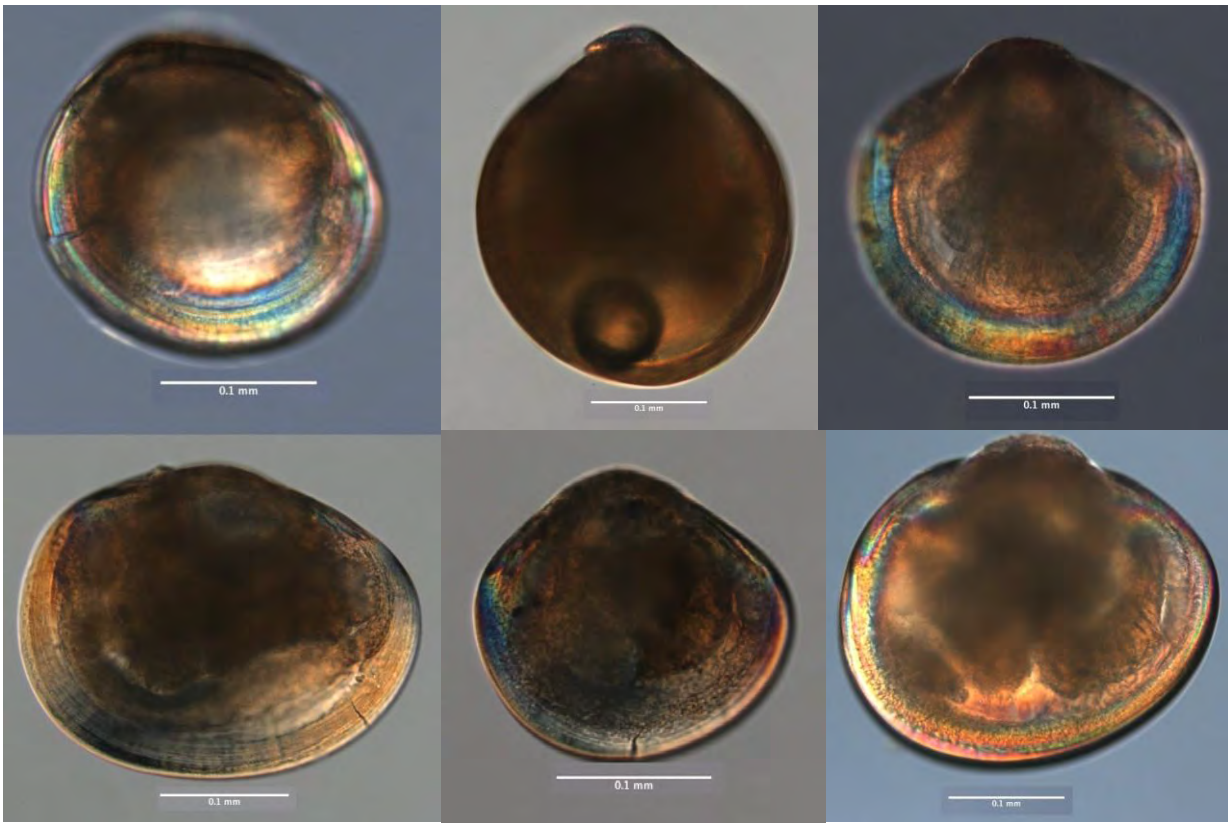
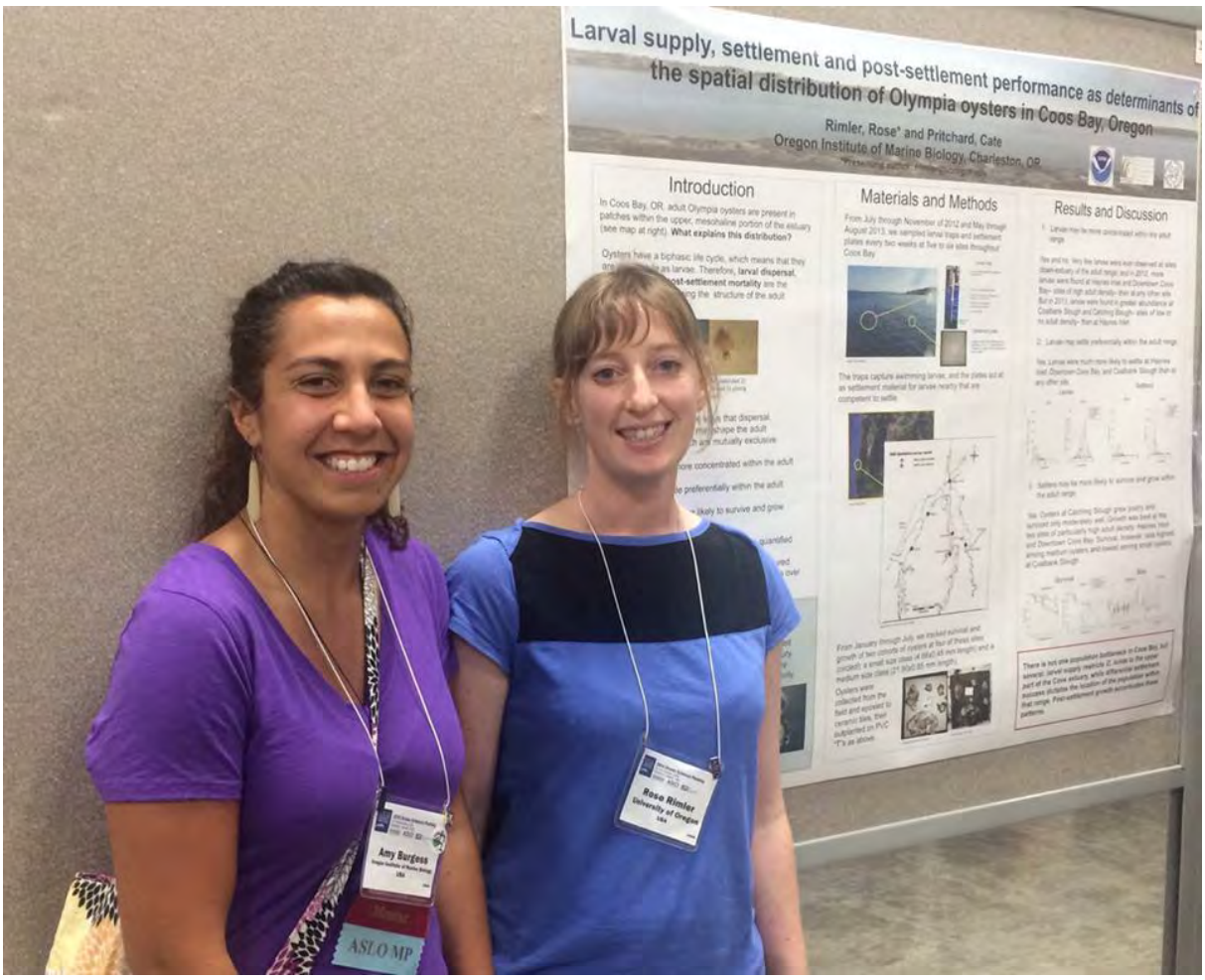


Figure 1. Larval bivalves identified through sequencing of the 18S gene region: (a) *Ostrea lurida*; (b) *Teredo navalis*; (c) species 1; (d) *Ensis* sp.; (e) *Mya arenaria*; (f) *Mytilus* sp.

Appendix II. Rose Rimler (right; graduate student supported by the NSC project) delivered a poster presentation during the Ocean Sciences Conference (Honolulu, HI; 23-28 Feb 2014):

Rose Rimler and Cate Pritchard. Oregon Institute of Marine Biology, University of Oregon.
Larval supplies, settlement and post-settlement mortality as determinants of the spatial distribution of Olympia oysters (*Ostrea lurida*) in Coos Bay, Oregon



Larval supply, settlement and post-settlement performance as determinants of the spatial distribution of Olympia oysters in Coos Bay, Oregon

Rimler, Rose* and Pritchard, Cate
Oregon Institute of Marine Biology, Charleston, OR
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Introduction

In Coos Bay, OR, adult Olympia oysters are present in patches within the upper, mesohaline portion of the estuary (see map at right). **What explains this distribution?**

Oysters have a biphasic life cycle, which means that they are only mobile as larvae. Therefore**, larval dispersal, settlement, and post-settlement mortality** are the major factors determining the structure of the adult population.

O. lurida life cycle: 1) larva with ciliated velum extended 2) oyster at settlement on glass slide; foot extended 3) young settler. Oysters are about 300µm at settlement.

There are several possible ways that dispersal, settlement, and mortality may shape the adult population, none of which are mutually exclusive:

1. Larvae may be more concentrated within the adult range
2. Larvae may settle preferentially within the adult range
3. Settlers may be more likely to survive and grow within the adult range

In order to test the first two possibilities, we quantified larval abundance and settlement concurrently throughout Coos Bay. To test the third, we measured survival and growth of oysters at four of these sites over six months.

Why Olympia oysters?

The Olympia oyster population has not fully recovered from overharvest in the late 19th and early 20th century. Restoring this species– the only oyster species native to the west coast of the U.S.– has become a high priority for many estuarine scientists along the west coast. A better understanding of the population dynamics of the bay could aid restoration efforts, which often involve out-planting juveniles or laying down shell or other hard material to collect spat.

Materials and Methods

From July through November of 2012 and May through August 2013, we sampled larval traps and settlement plates every two weeks at five to six sites throughout Coos Bay.

The traps capture swimming larvae, and the plates act as settlement material for larvae nearby that are competent to settle.

From January through July, we tracked survival and growth of two cohorts of oysters at four of these sites (circled): a small size class (4.66±0.45 mm length) and a medium size class (21.90±0.85 mm length).

Oysters were collected from the field and epoxied to ceramic tiles, then outplanted on PVC "T"s as above.

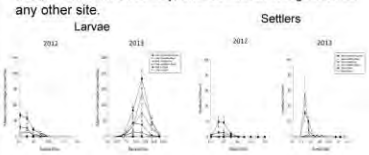
Results and Discussion

1. Larvae may be more concentrated within the adult range

Yes and no. Very few larvae were ever observed at sites down-estuary of the adult range; and in 2012, more larvae were found at Haynes Inlet and Downtown Coos Bay– sites of high adult density– than at any other site. But in 2013, larvae were found in greater abundance at Coalbank Slough and Catching Slough– sites of low or no adult density– than at Haynes Inlet.

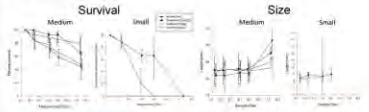
2. Larvae may settle preferentially within the adult range

Yes. Larvae were much more likely to settle at Haynes Inlet, Downtown Coos Bay, and Coalbank Slough than at any other site.



3. Settlers may be more likely to survive and grow within the adult range

Yes. Oysters at Catching Slough grew poorly and survived only moderately well. Growth was best at the two sites of particularly high adult density: Haynes Inlet and Downtown Coos Bay. Survival, however, was highest among medium oysters and lowest among small oysters at Coalbank Slough.



There is not one population bottleneck in Coos Bay, but several: larval supply restricts *O. lurida* to the upper part of the Coos estuary, while differential settlement success dictates the location of the population within that range. Post-settlement growth accentuates these patterns.